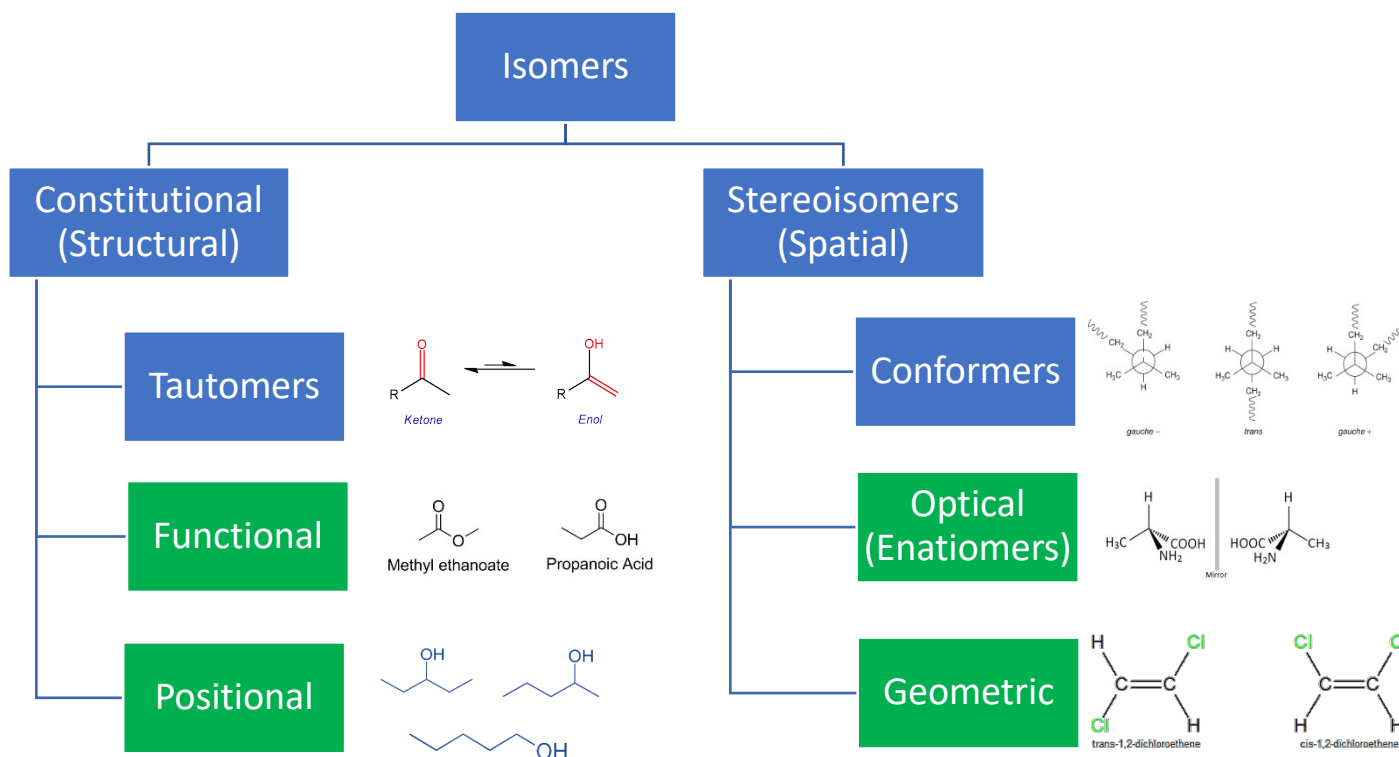


AFFIDAVIT

I, Heather L. Harris, state the following based on knowledge, information and belief:

1. I am a forensic chemistry consultant and assistant professor of forensic science employed by Arcadia University in Glenside PA. Prior to consulting and teaching, I was a forensic chemist at NMS Labs in Willow Grove PA and a forensic scientist in the chemistry section of the Bexar County Criminal Investigation Laboratory in San Antonio TX.
2. I have been involved in the field of chemistry, and specifically forensic chemistry, for over twenty years. In addition to studying chemistry and forensic science at the University of North Texas and The George Washington University, I have been an instructor in chemistry and forensic science at The George Washington University, Villanova University, and presently Arcadia University.
3. In addition to my education, training and professional experience as a forensic chemist, I am certified by the American Board of Criminalistics in two areas: Comprehensive Criminalistics and Drug Analysis. I participate in professional organizations, such as the American Academy of Forensic Sciences, the American Chemical Society, and AOAC International. The full details of my background are included in my attached CV.
4. Through his attorney, Mr. Owen has asked me to review the legal definitions of "cocaine" and its isomers under Minnesota and federal law to determine whether any substances criminalized under Minnesota law would be legal under federal law. As explained in this affidavit, it is my conclusion that the Minnesota definition of "cocaine" and its isomers is broader than the federal definition. As a result, certain substances would be controlled in Minnesota that would not be controlled under federal law.
5. To begin, an isomer is one of several molecular entities that have the same atomic composition but a different physical or spatial arrangement of the atoms in the molecule. As a result, isomers are different molecules and can have different physical and chemical properties.
6. Two main categories of isomers are constitutional isomers and stereoisomers. Constitutional, or structural, isomers have the same number of atoms of each element, but the atoms are connected in different ways. Stereoisomers, also known as spatial isomers, have the same number of atoms bonded together in the same way, but they differ only in their spatial arrangements in the molecules.
7. These two main categories of isomers each further contain a variety of more specific types of isomers. For example, constitutional isomers include tautomers, functional isomers, and positional isomers. Stereoisomers include conformers, optical isomers (enantiomers), and geometric isomers. The following figure illustrates these relationships.





8. The analysis in this affidavit focuses primarily on four isomer types: optical, geometric, positional, and functional. Optical and geometric isomers are types of stereoisomers. Positional and functional isomers are types of constitutional, or structural, isomers. These are highlighted in green in the figure above.
9. Under Minnesota law, cocaine is defined as follows:
 “Cocaine” means coca leaves and any salt, compound, derivative, or preparation of coca leaves, including cocaine and ecgonine, *the salts and isomers of cocaine and ecgonine*, and the salts of their isomers and any salt, compound, derivative, or preparation thereof that is chemically equivalent or identical with any of those substances, except decocainized coca leaves or extraction of coca leaves, which extractions do not contain cocaine or ecgonine.¹
10. Due to the italicized language above, all isomers of cocaine and ecgonine are included in the statutory definition of cocaine under Minnesota law. It does not appear that the term “isomer” is further defined or delimited under Minnesota law with respect to cocaine. Notably, Minnesota law does limit the isomers that are controlled with respect to other substances. For example, Schedule II includes “amphetamine, its salts, *optical isomers*, and salts of *optical isomers*.”² Thus, with respect to cocaine, the basic meaning of the

¹ Minn. Stat. §152.01(3a).

² Minn. Stat. §152.02 (3)(d)(1).

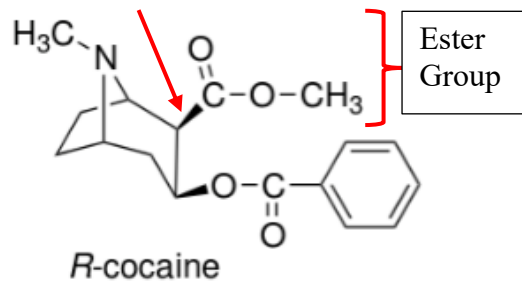
term “isomer” applies, which means that all constitutional isomers and stereoisomers of cocaine would be included in the definition of cocaine under Minnesota law

11. Federal controlled substance law is more specific. Under federal law, “cocaine” is defined to include:

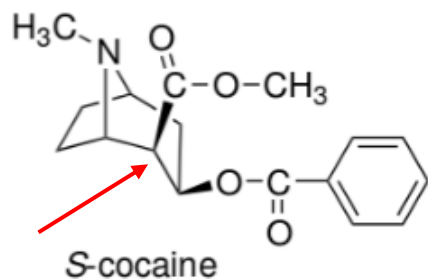
coca³ leaves, except coca leaves and extracts of coca leaves from which cocaine, ecgonine, and derivatives of ecgonine or their salts have been removed; *cocaine, its salts, optical and geometric isomers, and salts of isomers*; ecgonine, its derivatives, their salts, isomers, and salts of isomers; or any compound, mixture, or preparation which contains any quantity of the substances referred to in this paragraph.⁴

12. Therefore, federal controlled substance law criminalizes cocaine and its optical and geometric isomers. It does not criminalize any structural isomers of cocaine. In contrast, Minnesota law controls all isomers of cocaine, both structural isomers and stereoisomers. As a result, Minnesota law criminalizes substances that would not be controlled under federal law.

13. The term “cocaine” generally means the specific form of cocaine produced by the *Erythroxylum coca* plant. This form is specifically *R*-cocaine.



14. *R*-cocaine possesses one optical isomer, *S*-cocaine. These two forms are identical in their construction but are non-superimposable mirror images, just like a pair of human hands.



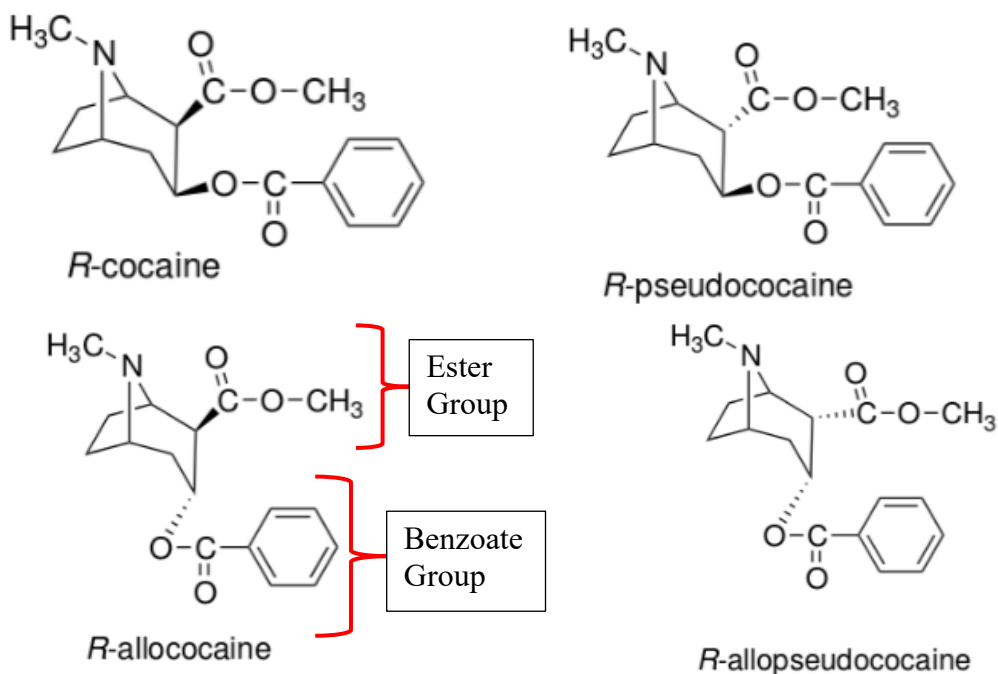
15. In these diagrams, the difference between the *R* and *S* forms is visible in the placement of the ester functional group at the back top right corner of the bridge structure in the *R*

³ 21 U.S.C. § 802(14).

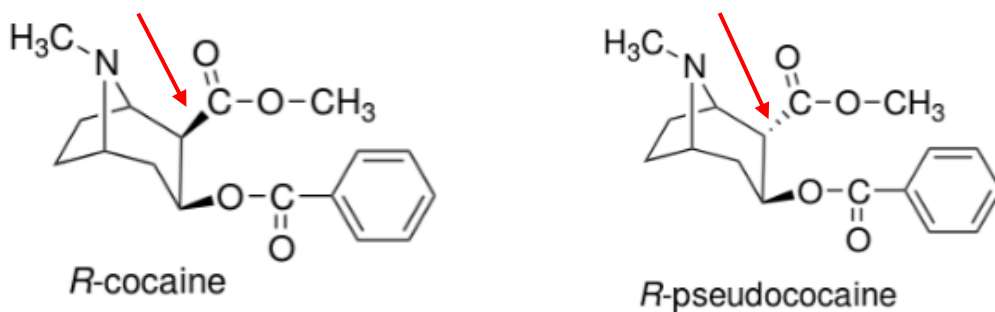
⁴ 21 U.S.C. § 812 Schedule II(a)(4).

form. It appears to have moved toward the viewer to the front top right corner of the bridge structure in the *S* form. These two forms are optical isomers.

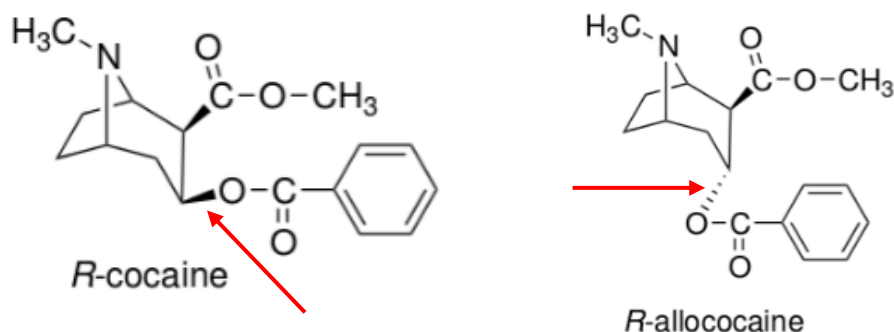
16. Cocaine, in both *R* and *S* forms, has a molecular weight of 303.35 g/mol and a molecular formula of $C_{17}H_{21}NO_4$. It contains four asymmetric carbon atoms that give rise to four geometric isomers: cocaine, pseudococaine, allococaine and pseudoallococaine.



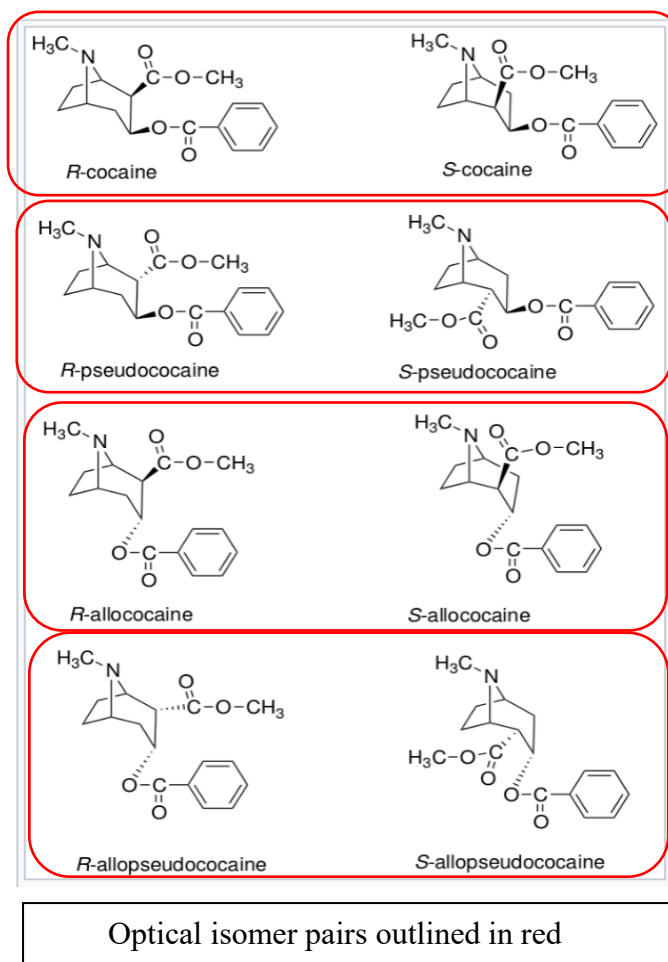
17. In these diagrams, the four different compounds have the same chemical structure. The differences between these geometric isomers exist only in the upward or downward orientation of the ester and benzoate functional groups in three-dimensional space.
18. For example, the ester functional group in cocaine is pointing upward, as indicated by the solid bold line. This same functional group in pseudococaine is pointing downward, as indicated by the dashed line.



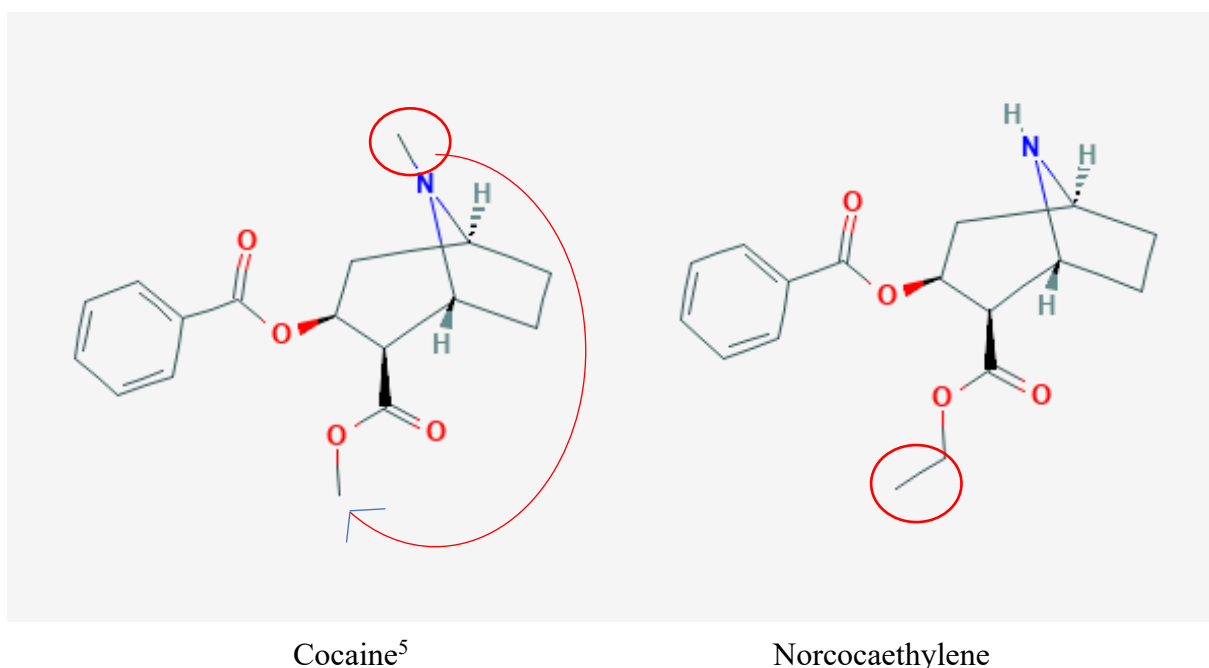
19. This difference in three-dimensional orientation is the only difference between cocaine and pseudococaine. As a result, they are considered geometric isomers.
20. Cocaine and allococaine are also considered geometric isomers because they differ in the orientation of the benzoate functional group. The group extends upward in cocaine and downward in allococaine.



21. Similar differences in orientation exist between all four of the geometric isomers.
22. Each geometric isomer listed above can also exist in either the *R* or the *S* optical isomer form. Thus, in total, cocaine possesses 8 different stereoisomers as seen in the figure below. All of these isomers would be controlled under both federal and Minnesota law.



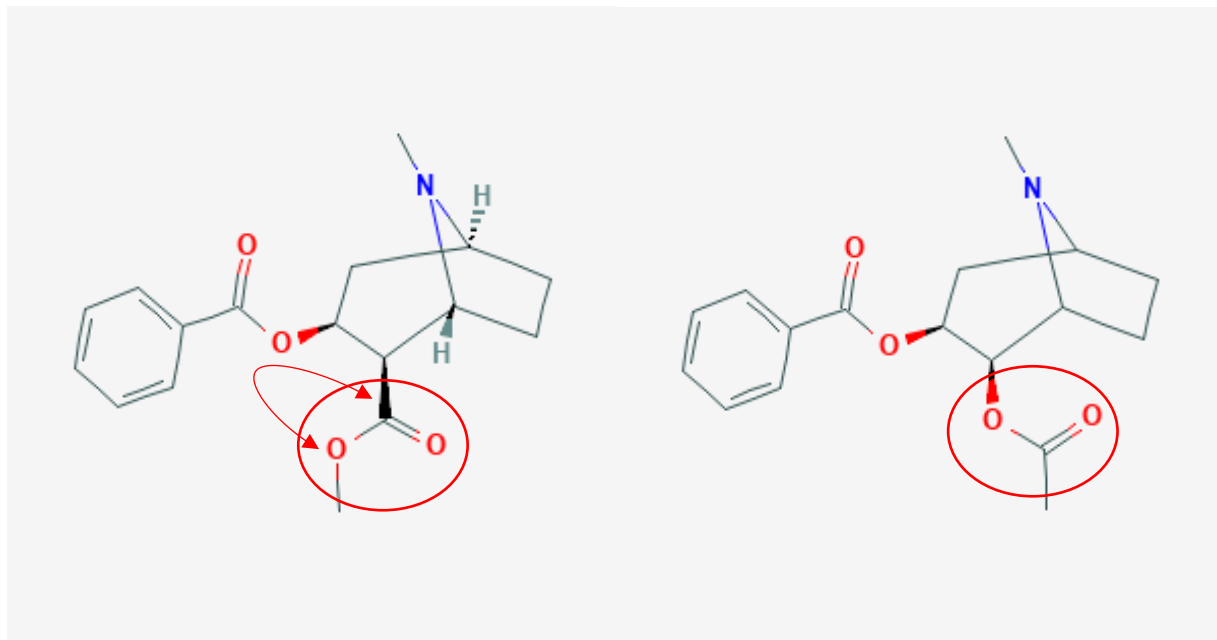
23. However, cocaine also possesses some structural isomers. These compounds would be controlled in Minnesota but would not be controlled federally.
24. One positional isomer of cocaine is the compound norcocaeethylene. Norcocaeethylene possesses the same atomic composition as cocaine, but the two compounds differ in the position of a small carbon group (CH_3) on the molecule.
25. Like cocaine and its optical and geometric isomers, norcocaeethylene has a molecular weight of 303.35 g/mol and a molecular formula of $\text{C}_{17}\text{H}_{21}\text{NO}_4$. Unlike cocaine and its optical and geometric isomers, which are simply different orientations of the same molecule in three-dimensional space, norcocaeethylene possesses the small carbon group at a different location on the molecule.



26. The diagrams above show cocaine on the left and norcocaeethylene on the right. The position of the relevant CH_3 group is on the nitrogen atom at the top of this cocaine diagram.
27. Norcocaeethylene is a positional isomer of cocaine because that relevant CH_3 group located on the nitrogen atom at the top of cocaine is now attached to the ester group at the bottom in norcocaeethylene. This change in position creates a new compound with the same molecular weight and the same molecular formula but with a different chemical structure.

⁵ PubChem, accessed March 17, 2021

28. The change in position of this carbon group does not create any new chemical functionality and it does not destroy any existing chemical functionality. As a result, cocaine and norcoethylen are positional isomers.⁶
29. Under the Minnesota statute, norcoethylen would be included as a controlled substance because it is an isomer of cocaine. It would not be a controlled substance under the federal statute because it is neither an optical nor geometric isomer. The federal definition of cocaine does not include positional isomers, such as norcoethylen.
30. Another compound that would be controlled in Minnesota but would not be controlled federally is reverse ester cocaine, a functional isomer. As with norcoethylen, reverse ester cocaine possesses the same molecular weight and formula as cocaine, but the two compounds differ in the bonding of the ester functional group to the bridge structure of the molecule.

Cocaine⁷

Reverse Ester Cocaine

31. The diagrams above show cocaine on the left and reverse ester cocaine on the right. The position of the relevant ester group is at the bottom of this cocaine diagram.
32. Reverse ester cocaine is a functional isomer of cocaine because that relevant ester group is bonded to the remainder of the molecule differently. In cocaine, the ester group is

⁶ Definition of “Positional Isomer” as It Pertains to the Control of Schedule I Controlled Substances, 72 Fed Reg, 67850 (Dec 3, 2007). It is noted that cocaine is not a Schedule I substance, but no federal definition of positional isomers for Schedule II substances exists as they are not included in the definition of cocaine.

⁷ PubChem, accessed May 15, 2021

attached to the molecule by a carbon-carbon bond. This creates the following sequence of atoms (from left to right) in the cocaine ester group: C-O-C-O.

33. However, in reverse ester cocaine, the ester group is attached to the molecule by an oxygen-carbon bond. This creates the following sequence of atoms (from left to right) in reverse ester cocaine: O-C-O-C.
34. This difference in bonding creates a new compound with the same molecular weight and the same molecular formula but with a different chemical structure. It also results in a change in chemical functionality. As a result, cocaine and reverse ester cocaine are functional isomers.
35. Under the Minnesota statute, reverse ester cocaine would be included as a controlled substance because it is an isomer of cocaine. It would not be a controlled substance under the federal statute because it is neither an optical nor geometric isomer. The federal definition of cocaine does not include functional isomers.
36. In conclusion, based on my education, training and experience in the field of forensic chemistry and on my evaluation described above, structural isomers of cocaine exist that would be controlled in Minnesota that would not be controlled federally. The federal definition restricts isomers of cocaine to optical and geometric isomers only. The Minnesota definition controls all isomers generally with respect to cocaine. Using the plain meaning of this term, the Minnesota definition of isomer, as it applies to cocaine, is much broader than the federal definition. As a result, these structural isomers would be criminalized in Minnesota while being legal federally.

Signed under the pains and penalties of perjury on this 8th day of July, 2021.

Heather L. Harris

Heather L. Harris, MFS, JD, ABC-CC, ABC-DA